USING A PROVEN SILICON CARBIDE SOLUTION TO GET A HEAD START ON FAST EV CHARGER DESIGNS

INTRODUCTION

The market for hybrid- and full-electric vehicles (EVs) is growing by 24% per year. Many factors are contributing to this market growth, including government incentives for the purchase and use of EVs, the increased availability of electric vehicle models, and environmental policies that have led to the introduction of heavy penalties on manufacturers who fail to reduce emissions of carbon dioxide and other gases from their cars. Like internal combustion engine vehicles, which must be refilled when they run out of fuel, EVs also require refueling, which is done by recharging. With an annual growth rate of 30%, the EV charging market has been growing even faster than the EV market. Charging time is becoming an issue as batteries with capacities over 80 kilowatts become standard. High-power charging stations that can deliver fast charging times will be required to meet the demand created by ever-increasing numbers of EVs.

DESIGN CHALLENGES

As a result, the electric vehicle charging market has been rapidly changing – with system requirements becoming more challenging, such as charging bigger capacity batteries in shorter durations and increasing efficiency standards. Size requirements also mean using smaller, more rugged modules with higher switching frequency operation, better thermal management, and careful integration with smart grid infrastructure. This requires a high degree of expertise and a variety of solutions that could also deal with evolving use cases like solar energy storage systems, centralized power factor correction (PFC), and multiple DC-DC stages. Level 3 fast charging stations must be capable of delivering up to 500 kW so that recharging times can be reduced to less than 30 minutes.

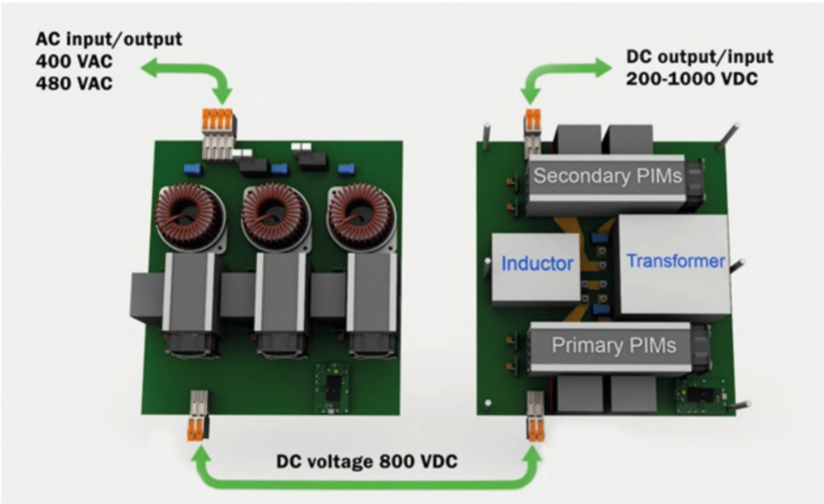

Figure 1: Proposed Silicon Carbide-based 25kW fast charging design

The charging station must also continuously communicate with the battery pack. Addressing this challenge, onsemi proposed a Silicon-Carbide-based 25kW DC charger design to be used as a building block to accelerate the development of level 3 fast chargers (figure 1). This design would consist of two fully autonomous boards: a six-pack three-phase AC-DC stage with PFC, a dual-active bridge isolated DC-DC converter, and an intermediate bus voltage of 800V to connect both.

This design would accommodate global grid voltages as input and be able to deliver up to 50A of output charging current. The complete list of design specifications is shown in figure 2. Twelve of these modules connected in parallel could provide 300kW of power from a charger cabinet that would communicate directly with the EV battery and be programmable via a user interface. Using this design as a starting point would allow manufacturers to work on the charging station's user interface in parallel with their hardware development process.

AC input	Voltage input rating	Three-phase 400 Vac (EU), 480 Vac (US)
	Max. input current	40 A
	Frequency	50/60 Hz
	Power factor	>0.99
	Efficiency	>96%
DC input	Output voltage	200 V to 1000 V
	Max. output power	25 kW
	Max. output current	50 A
Protections	Output	OVP, OCP, SC
	Input	UVP, OVP, inrush current
	Internal	Desat (gate driver), thermal (NTC on power device)
User Interface	Push buttons	Yes.
	GUI	Yes.
Communication buses	Internal	SPI, I^2C
	External	Isolated CAN, USB, UART
Environment	Operating temperature	0°C to 40°C
Max. mechanical dimensions	PCB	450 x 300 x 280mm (PFC and dc-dc stacked)
Standards	Regulation	Following guidelines described in EN55011 Class A
	EV systems	Following guidelines described in IEC 61851

Figure 2: Design specifications

Apart from the power stages, the proposed design would include multiple blocks implementing a range of other functions, including:

- Voltage and current sensing
- Communication (USB, UART, CAN, Ethernet)
- Auxiliary power
- Gate drivers (for the power stages)
- FPGA controller
- Isolation
- Data converters
- Memory (for data storage)

The complete block diagram for the proposed solution is shown in figure 3.

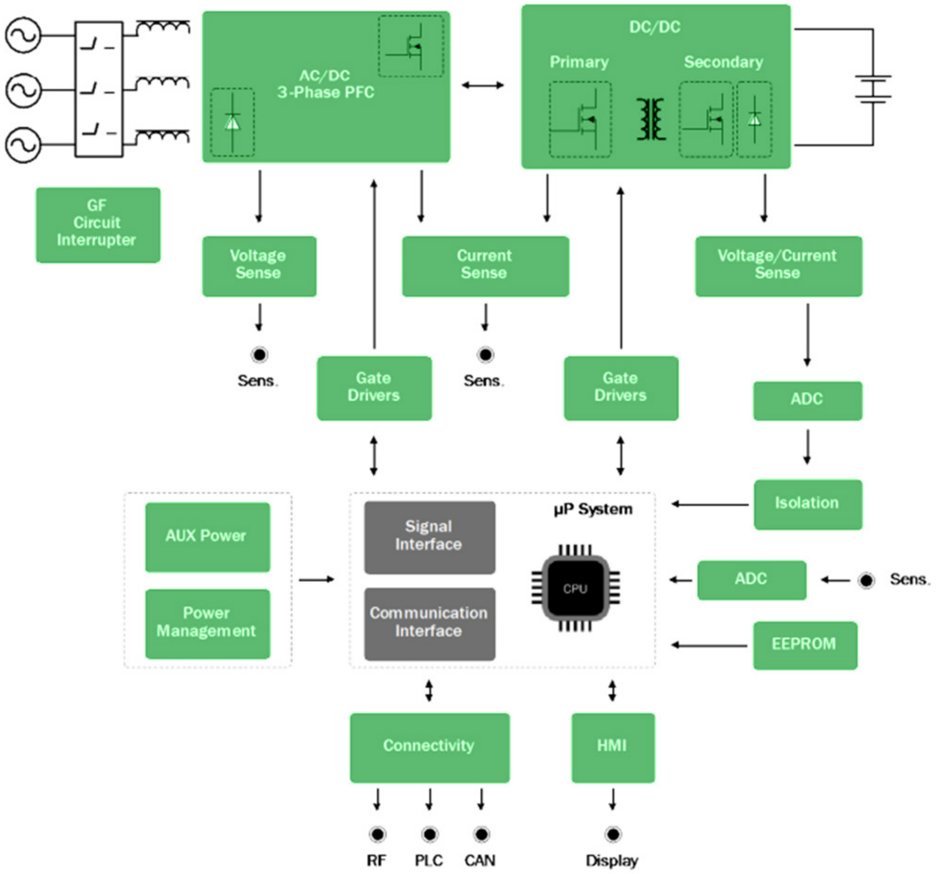

Figure 3: Block diagram for proposed 25kW DC fast charging solution

DESIGN SIMULATION AND MEASUREMENT

onsemi also suggested devices to perform each of these functions in the overall system and then performed various simulations on each power stage. These showed that the boost stage could achieve an efficiency of over 98.4%. While magnetizing inductance and turn ratio were key parameters that required careful consideration in the design of the transformer used in the dual-active bridge stage, overall simulations revealed that the proposed charging solution would perform in line with the design specifications. Simulations also revealed the total power losses in the Silicon Carbide devices, allowing an appropriate heat management strategy.

Analysis showed that discrete devices would not be able to dissipate the simulated power losses, but Silicon Carbide modules, using a combination of heat sinks and managed airflow, would be sufficient. The simulation results established an adequate basis for proceeding with the assembly of the boards for the final design, which was then tested for performance in line with simulation results and the overall design specifications. The measured results showed this 25kW design to be more the 96% efficient and confirmed the suitability of this Silicon-Carbide-based solution as a building block for DC fast charging stations.

USING THIS BUILDING BLOCK IN EV FAST CHARGERS

Designing, simulating, and testing a design topology requires advanced technical expertise and significant investment in costly research and development, which many companies do not have the resources to commit to. For this proposed EV fast charging solution, onsemi has done the hard work, so you don't have to, and they now invite you to take advantage of this proven solution. If you are looking for a way to develop an EV fast charger that you can bring to the market quickly, then you need to watch the webinar called "25kW Fast EV Charger Brick Design and Results," developed and delivered in partnership with Avnet. This webinar presents full details of the topology, simulation results, a complete bill of materials (BoM), and an overview of the test and measurement results.

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